The Effects of Prescribed Fire on Roosting Habitat of the Endangered Indiana bat, *Myotis sodalis*

I. Introduction

The proposed research addresses Task H of JFSP RFA 09–0001 and will investigate the compatibility of fuel treatments and fire management in the southern Appalachian Mountains with the conservation of the federally endangered Indiana bat (*Myotis sodalis*). Because it is a landscape-scale study, we expect our results to be used by land managers throughout the southern portion of the Indiana bat's range. This 3-year study will fill substantial knowledge gaps on the short- and long-term effects of prescribed fire on Indiana bat roost habitat.

1. Project Justification and Expected Benefits

The Indiana bat is an insectivorous bat distributed throughout much of the eastern U.S. (Fig. 1; Gardner and Cook 2002). Historically, there were millions of Indiana bats (Tuttle 1997), but <1 million were known by the 1960s when the species was federally listed. Despite federal protection and the initiation of recovery measures, the population declined 57% from 1965 to 2000 (Clawson 2002). Following a 15% population increase from 2000–2003, the U.S. Fish and Wildlife Service was confident that the long-term decline had halted (USFWS 2007). However, since late 2006, tens of thousands of *Myotis* bats in the northeastern U.S. have died due to a mysterious agent known as white-nose syndrome (Veilleux 2008) and biologists have predicted that the Indiana bat may be extinct in the northeastern U.S. within 5 years (Al Hicks, NY Dept. of Conservation, pers. comm.). Indiana bats are long-lived (>20 years) and have low fecundity (1 young/year) so recovery from this significant disturbance will be slow. Thus, conserving healthy populations of Indiana bats in the southern part of their range may be critical to the overall survival of the species.

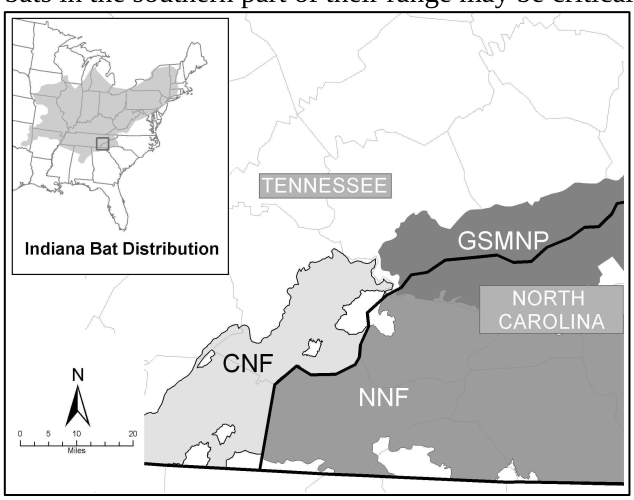

Figure 1. Distribution of the Indiana bat (inset) and study areas in eastern Tennessee and western North Carolina.

During summer, female Indiana bats form maternity colonies, give birth, and raise their young in cavities or crevices in large dead or damaged trees with open canopies. Most studies of summer roost habitat selection by female Indiana bats have been in the core of the species' range in Illinois, Indiana, and Michigan (e.g., Kurta et al. 2002, Whitaker et al. 2004, Carter and Feldhammer 2005) where individual colonies move among sets of suitable roosts and show long term fidelity to roosts and roost areas. Prior to 1995, it was thought that Indiana bats only formed colonies in hardwood forests in riparian areas in the northern portion of the species' range (USFWS 1999). However, the capture of a lactating female in upland habitat in Kentucky in 1994 and subsequent captures of reproductive individuals in the southern portion of the species' range prompted major revisions to national forest plans in Kentucky, Tennessee, and North Carolina (Krusac and Mighton 2002). Current management strategies involve protection of potential primary roosts and landscape-scale protection of preferred forest types.

Indiana bat maternity colonies were first discovered in the southern Appalachians in 1999 (Britzke et al. 2003); maternity roost selection has also been studied on the Cherokee National Forest (CNF) and the Nantahala National Forest (NNF; Fig. 1). Primary maternity roosts (Callahan et al. 1997) in the southern Appalachians are often under the sloughing bark of dead southern yellow pines, mainly shortleaf pine (*P. echinata*), with >50% bark but, in the study by Britzke et al. (2003) roosts were unsuitable 1 year after they were found. The majority of roosts are on mid and upper slopes in mixed pine-hardwood stands, but some non-pine roosts have been found near streams. A major benefit of the research we propose is the opportunity to compile new and existing information on maternity habitat requirements and distribution, which is a primary recovery action for Indiana bats (USFWS 2007). Furthermore, our research will relate roost site selection to prescribed burning, as recommended by Krusac and Mighton (2002).

In the southern Appalachians, fire has become an important tool for the restoration of oak (*Quercus*) and yellow pine (*Pinus* subgenus *Diploxylon*) forests (Elliott et al. 1999, Waldrop and Brose 1999) because these species are valuable for wildlife, timber, and biodiversity. On federal lands in this region, resource managers implement landscape-scale (500–4000 ac) dormant season burns using burn protocols designed to mimic natural lightning-set fires on ridgetops. Paleoecological analyses show that oaks and pines were common in prehistoric forests in this region (Delcourt and Delcourt 1997), most likely maintained by a combination of frequent human and lightning-set fires (Van Lear and Waldrop 1989). Lafon et al. (2007) predicted that in the absence of regular fire, yellow pines would disappear from south- and west-facing slopes, and ultimately would be replaced by hardwoods, even on ridgetops. In addition to restoring native pine-oak communities, frequent burning should result in open-canopy woodlands (Lafon et al. 2007) that are more sustainable and less prone to insect infestations and disease than the closed canopy forests that have developed in the absence of fire (Van Lear et al. 2004).

Tiedemann et al. (2000) caution that the effects of large-scale prescribed burning on wildlife are largely unknown and recommend that managers consider the effects of fire on all important resources prior to using fire as a primary management tool. Resource managers need more information on the relationship between large-scale habitat perturbations designed to restore woodlands and the maintenance of Indiana bat maternity habitat (USFWS 2007). In this study, we will investigate the compatibility of large-scale burns with conservation and management of Indiana bats. Protection of Indiana bats is one of the key factors in determining when and where managers can implement burns in the southern Appalachians (see letter of support from USFWS) and uncertainty about the direct and indirect effects of fire on Indiana bats can prevent or delay the effective use of fire as a restoration tool. Although a recent study focused on the direct effects of fire on Indiana bats and their behavior (Dickinson et al. *in* press), few data are available on the indirect effects of prescribed fire on Indiana bat habitat, particularly roosting habitat.

Fire may be necessary for the persistence of yellow pine forests in this region (Lafon et al. 2007) and, if pines are important roost types, fire could be a critical management tool for sustaining Indiana bat roosting habitat. In addition, open canopy conditions created by frequent burning could be ideal for Indiana bats, as females in the midwestern U.S. select trees with high solar exposure (Kurta et al. 2002, Carter and Feldhammer 2005). Snags are critical habitat for Indiana bats (USFWS 2007) and, currently, yellow pine snags are abundant in the southern Appalachians due to a massive pine beetle outbreak in the late 1990s and early 2000s. However, one of the primary justifications for this study is that little is known about how prescribed fire for habitat restoration and fuels management affects existing snags and whether fire can create a sufficient number of snags to replace those that are destroyed. Net recruitment of large snags varies with fire history and intensity. For example, after a long period of fire exclusion, prescribed burns in the western U.S. result in a net loss of large snags (Horton and Mannan 1988, Bagne et al. 2008). No studies have been conducted to determine the response of snags to prescribed fire in the eastern U.S. Tiedemann et al. (2000) and Bagne et al. (2008) suggest that protection (i.e., removal of debris near the base of trees prior to burning) of large snags preferred by wildlife might be warranted if snag loss is a concern. However, protection of individual snags is not feasible in the large-scale burns being implemented in the southern Appalachians. Further, because snag suitability varies with a complex of biotic and abiotic factors other than fire (Bagne et al. 2008), protection of individual trees may not be a sound conservation strategy. Because fire plans in this region involve prescribed fire at intervals of 2–12 yrs, it is possible that snag recruitment and reduction will reach equilibrium or that snags may show resilience with repeated fires (Holden et al. 2006). Thus, periodic burning could be used to sustain snag populations in conditions suitable for Indiana bat maternity roosts. The proposed study will provide managers with a better understanding of the effects of burning on snag populations, which will aid in the development of prescribed fire plans that are consistent with Indiana bat conservation and recovery. The primary goal of this study is to generate a substantial set of data to inform management decisions and policy guidelines for balancing the needs of Indiana bats with the needs of the fire-adapted ecosystem in which they exist.

2. Project Objectives and Hypotheses

Objective 1. Effects of prescribed fire on snag population dynamics

We will determine snag population dynamics in prescribed fire treatment and control sites at multiple landscape positions. We will test the hypothesis that populations of large snags are affected by fire, and that responses vary with slope position, fire intensity, and snag characteristics. The primary product will be a large dataset on the effects of fire on individual trees that can be used to model which fire management activities can be implemented while maintaining key habitat features, and how fire spread and severity from prescribed fires vary in their impacts on desired habitat features.

Objective 2. Landscape-scale roost tree availability

We will determine the availability of snags suitable for Indiana bats in multiple landscape positions in stands with a range of prescribed fire histories. We will test the hypothesis that roost availability varies with landscape position and fire history. The data on roost availability at the landscape scale will be valuable for management of Indiana bats and will provide insight into the fire activities that can be implemented, where on the landscape fuels management can be implemented, and how habitats can be sustained across broad landscapes.

Objective 3. Indiana bat roost tree selection in relation to fire history, and stand and landscape characteristics

We will identify the multi-scale characteristics of trees used as day roosts by Indiana bats in pine-hardwood stands in landscapes managed with prescribed fire. We will test the hypothesis that roost habitat selection is non-random with respect to fire history, and tree, plot, stand, and landscape characteristics. Resulting information on roost habitat selection will answer the question of where on the landscape fuel management activities can be planned to maintain and improve key habitat features for Indiana bats.

II. Methods

1. Study Sites

The study will take place in 3 areas (Fig. 1) in the southern Appalachian Mountains: 1) CNF (Cherokee National Forest, Polk and Monroe counties, TN, 2) NNF (Nantahala National Forest, Cherokee County, NC), and 3) GSMNP (Great Smoky Mountains National Park, Swain County, NC; Blount and Sevier counties, TN). Pine-hardwood forests are extensive in the 3 areas, with major canopy dominants including shortleaf pine, Table Mountain pine (*P. pungens*), pitch pine (*P. rigida*), Virginia pine (*P. virginiana*), white oak (*Q. alba*), scarlet oak (*Q. coccinea*), blackjack oak (*Q. marilandica*), chestnut oak (*Q. prinus*), black gum (*Nyssa sylvatica*), sourwood (*Oxydendrum arboreum*), and red maple (*Acer rubrum*). Mean annual precipitation is 56 in and mean annual temperature is 55 °F. The 3 areas have similar burning protocols: the burn area is ignited by incendiary spheres dropped on ridgetops.

2. Sampling Design

Objective 1. Effects of prescribed fire on snag population dynamics

In each study area we will establish 2 treatment and 2 control sites (generally 1000–4000 ac) to assess the effects of prescribed fire on existing snags and creation of new snags. Treatments will be burned between March and April 2010. Treatment and control sites will be in mixed pine-hardwood forests that have not experienced fire in the past 10 years. In each site we will establish 1 transect on the upper slope, 1 at mid slope, and 1 on the lower slope. Transects will be in habitats that are likely to contain suitable roosts for Indiana bats based on current knowledge of suitable roost habitat in the region. Pre-burn assessments will be conducted in the fall/winter of 2009–2010 and post-burn assessments in both treatment and control sites will be conducted in May–July of 2010–2012.

Objective 2. Landscape-scale roost tree availability

To test the effects of fire history and landscape position on roost availability we will establish transects in stands containing suitable Indiana bat habitat that vary in burn history and landscape position. Stands will be similar in age, forest type, and basal area to those used by Indiana bats in this study and previous studies in this region. We will survey 2 transects of each unique combination of burn history (unburned, burned once in past 10 yrs, or burned twice in past 10 yrs) and slope position (lower, mid, or upper) in each study area. A total of 54 transects (18 transects per study area) will be sampled. Roost availability assessments will be conducted in late summer 2010 and 2011.

Objective 3. Indiana bat roost tree selection in relation to fire history, and stand and landscape characteristics

To obtain more refined information on the multi-scale characteristics of roosts used by Indiana bats in the southern Appalachians, we will conduct radio telemetry studies. We will track Indiana bats in each study area during the maternity periods (15 May–15 August) of 2010 and 2011. Because roosts of individual bats are often clustered in specific areas (Miller et al. 2003), our goal will be to capture and track as many bats as we can rather than monitoring a few bats intensively. To increase the probability of locating maternity roosts, we will focus telemetry on adult females and juveniles.

3. Field Measurements

Objective 1. Effects of prescribed fire on snag population dynamics

Transects in treatment and control sites will begin at random points situated within each slope class and will follow the contour line. Optimal transect width (33–132 ft) will be determined during pre-treatment sampling; a width will be selected that minimizes variance and simplifies snag detection (Bate et al. 1999). Because we are most interested in the effects of fire on snags that are suitable as Indiana bat roosts, we will measure and tag all live and dead trees ≥8 in dbh (diameter at breast height) along each transect until 40 snags have been recorded. The length of each transect will be measured to estimate snag density. For each tree, we will record species (if possible), height, dbh, and cause of mortality (if possible). To evaluate decay status of snags ≥8 in dbh we will record branch state (by size and number), bark tightness, percent remaining bark, and surface wood hardness (Bagne et al. 2008). We will take the same measurements on all standing dead trees and new snags during the post-burn assessments. Trees will be marked with numbered brass tags and we will record coordinates for each dead tree with a GPS unit (Trimble Navigation Ltd., Sunnyvale, CA). To measure loss and recruitment of small snags, we will count the number of snags 4–8 in dbh encountered during pre- and post-burn surveys. To measure fire temperature and residency, we will place 28 HOBO® dataloggers 10 in above ground in each transect in treatment sites prior to burning. Ten dataloggers will be assigned to pine snags within each transect and the remaining 18 data loggers will be set at opposing positions along the upper and lower edges of each transect at intervals of uniform length (approximately 1 unit every 82 yd). Past disturbances such as beetle or ice damage will be recorded for each transect.

Objective 2. Landscape-scale roost tree availability

For each burn history/slope position combination, we will select a random starting point for a belt transect of optimal width (see objective 1). We will measure all live and dead trees ≥8 in dbh along each transect until 40 dead trees have been recorded. For each tree we will measure species, height, dbh, beetle damage, and decay characteristics as outlined above. For standing burned trees we will measure the height of the fire scar on the bole and cause of mortality (if possible). We will take GPS coordinates for the start and end points to determine transect length.

Objective 3. Indiana bat roost tree selection in relation to fire history, and stand and landscape characteristics

We will deploy stacked mist nets to capture bats over road/stream corridors for 3–4 h after sunset. Captured bats will be identified, sexed, aged, measured (forearm length and weight), and banded with a unique aluminum forearm band. We will attempt to track 6–8 adult female or juvenile Indiana bats per study area per summer. For selected bats we will attach a radio transmitter (21-day; Holohil Systems, Ltd., Canada) and bats will be released at the point of capture. We will use a 3-element Yagi antenna and a receiver (Wildlife Materials, Murphysboro, IL) to locate at least 2 day roosts for each bat, as feasible. To differentiate primary and alternate roosts (Callahan et al. 1997), emergence counts will be conducted at each roost.

For each roost tree, we will identify a random tree with visible roost potential ≥165 ft from the roost in a random direction. For each focal (roost or random) tree, we will record species, dbh, and height and distance to and height of the closest tree ≥4 in dbh and the closest tree the same height or taller. We will measure all trees ≥4 in dbh to calculate live and dead tree basal areas in a 0.25 ac plot around each focal tree. For live trees, we will record species, dbh, height relative to focal tree, and roost potential, and for dead trees we will record species, dbh, and decay stage (as in Objective 1). We will count all saplings along 4 transects (6.5 ft-wide) from plot center to edge. For each quarter plot, percent canopy closure will be estimated to the nearest 25%. We will GPS roosts and capture sites to plot with habitat data in ArcGIS, using a distance-based analysis to quantify roost habitat selection at the landscape scale (Conner et al. 2003). For roost and random points on the landscape (defined by boundaries of bat travel during our study, Miles et al. 2006) we will calculate distance to nearest stream, forest edge, opening, and to 3 types of stands with a pine component: unburned, burned once in past 10 yrs, or burned twice in past 10 yrs. Elevation, aspect, and slope of roost and random locations will be determined from U.S. Geological Survey digital elevation models.

4. Data Analysis

Objective 1. Effects of prescribed fire on snag population dynamics

We will use mixed linear models to test, by period, the effects of burn and slope position (fixed effects) on snag density, snag volume, and decay value (Table 1). Fire temperature and residency (transect means), and disturbance history (e.g. pine beetle) will be incorporated into tests as random effects. We will also examine specific factors related to loss and gain of snags. We will use categorical models to model snag fate (loss or creation) in relation to size class, species, decay state, and fire spread and temperature (transect means or values for individual snags).

Objective 2. Landscape-scale roost tree availability

We will use mixed linear models to test the effects of fire history and slope position on snag density, snag volume, and decay value (Table 1). Time since burn and disturbance history will be used as random effects for burned stands.

Objective 3. Indiana bat roost tree selection in relation to fire history, and stand and landscape characteristics

We will develop a set of a priori models and use Akaike's Information theoretic procedures (Burnham and Anderson 2002) to select plausible logistic regression models and important variables to explain roost habitat selection. We will test one set of candidate models related to tree and plot characteristics for roosts and random trees and a second set of candidate models to compare stand and landscape traits for roosts and random points on the landscape (Table 1).

Table 1. Response and independent variables, and covariates for analyses for 3 research objectives.

Objective	Response	Independent Variables
1. Effects of prescribed fire on snag populations	snag density	burn (treatment or control)
	snag volume	slope position
	decay value	fire temperature
	snag fate	rate of fire spread
		disturbance history (e.g., beetle damage, ice)
		period (pre, 2-mo. post, 1-yr post, 2-yr post)
2. Landscape-scale roost availability	snag density	fire history
	snag volume	slope position
	decay value	time since burn
		disturbance history (e.g., beetle damage, ice)
3. Roost tree selection	use (1/0)	tree and plot characteristics
	primary/secondary	stand age
		position (aspect, elevation, and slope)
		distance to landscape features
		distance to burns

5. Materials

We require specialized equipment for transects and roost plots, including GPS units, 2 Husky Fex21-HD dataloggers, a range finder for height measurements, brass tree tags, and dbh tapes. For the radio telemetry study we require radio transmitters, mistnets, poles, and ropes. One receiver and antenna will be provided by USFWS and 2 receivers will be provided by the U.S. Forest Service, Southern Research Station. We will use U.S. Forest Service vehicles from the Southern Research Station in Asheville, NC.

III. Project Duration and Timeline

This project will last 3 years, with a start date on 1 Oct 2009 and completion on 30 Sept 2012. Pre-burn work for Objective 1 will take place between Oct 2009 and Jan 2010. Post-burn assessments for this objective will be from May–July 2010–2012. Roost availability transects for Objective 2 will be sampled from May-Sept. 2010–2011. We will conduct the telemetry study on Indiana bats from 15 May–15 August 2010 and 2011 and the roost habitat data collection from 15 May to end September 2010 and 2011.

Table 2. Timeline for field treatments.

		Work Periods For Field Treatments			
Objective	**Year**	**Oct.-Jan.**	**Mar.-Apr.**	**May-July**	**Aug.-Sept.**
1	FY2010	Pre-burn	Rx fires	Immed. post-burn	
	FY2011			1-yr post-burn	
	FY2012			2-yr post-burn	
2	FY2010			Roost availability assessment	
	FY2011			Roost availability assessment	
	FY2012				
3	FY2010			Roost selection	
	FY2011			Roost selection	
	FY2012				

Table 3. Project milestones and delivery dates.

Objective	Project Milestone	Description	Delivery Dates
1	Pre-burn	36 transects in burn/control sites prior to FY10 burns	Feb. 2010
	Immed. post-burn	36 transects in burn/control sites after FY10 burns	July 2010
	1-yr post-burn	36 transects in burn/control sites 1-yr after FY10 burns	July 2011
	2-yr post-burn	36 transects in burn/control sites 2 yr after FY10 burns	July 2012
	Data analysis	Compilation and analysis of transect data	Sept. 2012
2	Roost availability	54 transects in 3 study areas	Sept. 2011
	Data analysis	Compilation and analysis of transect data	May 2012
3	Roost selection	Telemetry and roost habitat data collection	Sept. 2011
	Data analysis	Compilation and analysis of roost habitat data	May 2012

IV. Project Compliance - NEPA and other clearances.

The U.S. Fish and Wildlife Service has engaged in formal consultation under Section 7 with the U.S. Forest Service and National Park Service regarding management activities in areas assumed to contain Indiana bat habitat in western North Carolina and eastern Tennessee. The 3 agencies have committed their support to this project (see letters of support). The PI (Susan Loeb) holds a federal recovery permit for

Indiana bats and the Co-PI (Joy O'Keefe) has an application in review for a federal recovery permit for Indiana bats. Both Loeb and O'Keefe have held permits from the state of NC for ≥5 years and, in light of their bat experience, neither should have any difficulty in obtaining state permits from TN.

V. Budget

Table 4. Proposal Budget Summary for FYs 2010, 2011, and 2012

Budget Item	2010		2011		2012		
	Requested	Contributed	Requested	Contributed	Requested	Contributed	**TOTAL**
LABOR	143,540	17,310	141,510	17,830	86,215	18,365	424,770
TRAVEL	8,950	16,800	6,980	16,800	4,750	4,200	58,480
VEHICLES	3,340	5,550	3,340	3,640	0	1,820	17,690
Capitalized Equipment:	30,250	26,450	0	2,700	0	0	59,400
Materials and Supplies:	8,375	0	5,875	0	250	0	14,500
Science Delivery and Application:	0	1,400	0	1,400	2,000	5,400	10,200
Other: Prescribed fires		180,000					180,000
Total Direct Costs	194,455	247,510	157,705	42,370	93,215	29,785	765,040
Indirect Costs: 2% all costs	3,889		3,154		1,864		8,907
Total Contributed Funding all years		**247,510**		**42,370**		**29,785**	**319,665**
Total Requested Funding all years	**198,344**		**160,859**		**95,079**		**454,282**

VI. Research Linkage

The results of this study will complement the study conducted by Dickinson et al. (Injury and Mortality Risks from Wildland Fire Smoke and Heat Exposures for Endangered Indiana Bats (*Myotis sodalis*) in Maternity Roosts; funded by JFSP in 2006) which determined the direct effects of growing season prescribed fires on Indiana bats (e.g., toxicology, smoke effects) and movements and roost use of bats during and immediately following a prescribed fire. Data from the two studies will provide managers with extensive information to guide prescribed fires within the range of the Indiana bat. Two other studies on Indiana bat roost site selection within the study area will provide additional data on roosting habitat. A joint project between the NC Wildlife Resources Commission (End. Species Sec. 6) and the Eastern Band of Cherokee Indians facilitated a study of Indiana bat distribution and roost ecology in western NC in the summer of 2008. The Tallassee Board has agreed to fund a study (Summer 2009) on the roost ecology of Indiana bats and northern long-eared bats (*M. septentrionalis*) in the 3 study areas identified in this proposal.

Table 5. Current and Pending Research Grants

Grant Program	Project or Proposal Description/Identification	Funding Amount	Project Completion Date
USFWS End. Species Sec. 6	NC Endangered Species-E-3: Indiana bat (*Myotis sodalis*) summer distribution and roost tree selection in southwestern North Carolina	$15,000	June 2009
Tallassee Fund	Roost Ecology of Indiana bats in Summer 2009	$28,500	May 2010

VII. Deliverables and Science Delivery

Annual progress reports will be completed by 30 September 2010–2012. We also plan to develop a website that will provide details on the study including the proposal, a detailed study plan, and results, presentations, and publications as they become available. A 1½ day workshop and field tour will be convened at the end of the project to provide a forum for discussion on the use of prescribed fire within the range of the Indiana bat by managers and biologists of southern Appalachian National Forests, the Great Smoky Mountains National Park, and other state and federal agencies. The workshop will include presentations, a panel discussion, and a field tour. We will present study results in poster and oral presentations at regional and national meetings and will publish ≥ 2 refereed manuscripts on this research. Furthermore, we will provide resource managers with spatial databases and a model of snag dynamics in relation to prescribed fires and landscape position, and a detailed spatial database for Indiana bat roosts on all 3 federal properties.

Table 6. Deliverable, Description and Delivery Dates

Deliverable Type	Description	Delivery Dates
Website	Provide up-to-date detailed information on the study. The website will be continuously updated as new information and products become available.	Sept. 2010-2012
Workshop and Field Tour	1½ day workshop for managers & biologists will be convened to provide information on the effects of prescribed fire on Indiana bats and a forum for discussion of the future use of prescribed fire within the range of Indiana bats.	Sept. 2012
Poster	Preliminary results will be presented at regional or national meetings (e.g., Southeast Association of Fish and Wildlife Agencies, SAMAB Annual Meeting)	Fall 2011
Presentation	Final results will be presented at national meetings (e.g., The Wildlife Society).	Fall 2012
Refereed Pub.	Effects of fire on snag population dynamics	May 2013
Refereed Pub.	Roost tree selection and availability in relation to fire	May 2013
Spatial Dataset	Locations and attributes of Indiana bat roost trees	May 2012
Spatial Dataset	Locations and attributes of trees in transects surveyed for objectives 1 & 2	Sept. 2012
Computer Model	Categorical model of snag fates in relation to size class, species, decay state, and fire spread and temperature.	May 2013

VIII. Roles of Investigators and Associated Personnel

The Principal Investigator is a Research Ecologist with the U.S. Forest Service, Southern Research Station. The PI will ensure the project is conducted as proposed, manage all budgetary aspects of the project, supervise the post-doc, assist in the data analysis and interpretation, and assist in the organization of the workshop. The Co-PI will be hired as a post-doc and will have year-round responsibility for managing field data collection and personnel as well as data management and analysis. The federal cooperators will facilitate the prescribed burns, aid in sampling design, and offer logistical support for field treatments. The federal fiscal representative will manage project funds for the U.S. Forest Service.

Table 7. Roles and Responsibilities of Associated Personnel

Personnel	**Role**	**Responsibility**
Susan C. Loeb	Principal Investigator	Research lead, primary contact
Joy M. O'Keefe	Co-Principal Investigator	Research lead, field coordination
Rob Klein	Federal Cooperator	Great Smoky Mountains National Park coordination
Laura Lewis	Federal Cooperator	Cherokee National Forest coordination
Steve Lohr	Federal Cooperator	Nantahala National Forest coordination
Shelley Gates	Federal Fiscal Representative	Will receive funds on behalf of the Southern Research Station

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